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RESEARCH PAPER

Resource Availability Versus Resource Extraction in Forests: Analysis of Forest Fodder System in Forest Density Classes in Lower Himalayas, India

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Abstract Particularly in developing countries, forests provide feed for livestock in the form of fodder for stall-feeding and grazing in forest areas. Extraction of fodder resources from forests often leads to forest degradation. An attempt has been made to qualify extend of biomass extraction from forests and to compare forest fodder dependence of households in a number of forest density classes in the mountainous region of Himalayas, in Uttarakhand state in India, according to livestock owners' perspectives. Information was obtained from a survey of livestock feed and fodder collection and utilization from 316 randomly selected households distributed across four government-defined forest density classes, namely very dense forest, moderately dense forest, open forest and scrub. Households obtained feed and fodder for livestock from three sources, i.e. forest areas, non-forest areas and local markets. Daily feed consumption per adult cattle unit varied according to source, ranging from 9.85 to 14.70 kg from forest areas, 7.40 to 11.14 kg from non-forest areas, and less than 1 kg from local markets. The dependency of households on fodder for livestock differed significantly between households located in each forest density classes. The current forest fodder extraction rate is likely to be unsustainable. Measures identified to reduce the extraction rate include greater use of alternative fodder sources and managing small patches of the natural forests adjoining dependent villages for fodder production through community participation.

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Introduction

Forest degradation mainly in developing countries in the form of conversion of dense forests to open forests has several direct and indirect causes, including agricultural expansion into forestland, litter removal from the forest floor for organic fertilizer production required for cash crops, grazing and lopping pressure on forests due to low fodder production on farm land (Prabhakar et al. 2006; Singh 2006; Baland et al. 2007) uncontrolled grazing on common land and overstocking of livestock on pasture land (Kumar and Shahabuddin 2005). Several researchers have observed that forest fodder extraction is a key source of forest degradation, e.g. Khanduri et al. (2002), Prabhakar et al. (2006), Singh (2006) and Baland et al. (2007). Grazing in forests influences the plant community structure (Yadav and Gupta 2006) and is frequently blamed for loss of species diversity in forests due to selective browsing by animals, soil erosion (Kumar and Shahabuddin 2005; Sharma et al. 2009), depressed growth of seedlings and saplings, and reduced recruitments due to trampling (FAO 1974; Moench 1989; Kumar and Shahabuddin 2005). Overall, forest degradation by livestock leads to loss of fodder biomass, causing a vicious cycle of reducing supply and increasing demands for fodder resources. Biomass extraction from forests also leads to reduced carbon stocks, wildlife habitat and other ecosystem services of forests. From a development policy perspective as well as the current debate on climate change keeping forests at centre stage, the more important question is whether it is possible to meet forest conservation objectives simultaneously with extraction of fodder for livestock.

In the middle Himalayas of India, estimates of fodder extraction from forests vary from 25 to 66 % of total fodder supply, as reported by Singh and Naik (1987), Bajracharya (1999), Singh (1999) and Tripathi (1999). The contribution is lower at about 26–43 % in the lower hills as reported by Singh (1999) and Tripathi (1999). The high contribution of forest fodder may be due to limited cultivation of fodder on farms and free access in forests for fodder. Tewari et al. (2003) reported that farm fodder cultivation is restricted to only about 1 % of the cultivated area in the entire Himalayan region, due to the preponderance of marginal and small landholdings and prevalent subsistence agriculture.

Adequate provision of feed is essential to livestock productivity (Nayak et al. 2012). In India, the annual livestock feed requirements of dry matter, total digestible nutrients and digestible crude protein have been estimated as 624, 322 and 30 MT respectively (Bakshi and Wadhwa 2004), with deficit varying from 30 to 35 % (Bakshi and Wadhwa 2004; Reddy et al. 2006). More recently, Roy and Singh (2008) estimated that the annual requirement of dry and green fodder is 569 and 1025 MT respectively against the availability of 385 and 356 MT respectively.

In recent years, rapidly growing animal and human populations, coupled with the unrestricted grazing by livestock, has led to a decline in the density of vegetative cover and the severe impoverishment of the forests of India (Ministry of Environment and Forests 2003 and 2009). This has already altered plant species composition towards

dominance of useless species. These changes are reducing livestock productivity due to scarcity of green fodder, leading to reduced production of green manure and lower crop yields, ultimately leading to a vicious circle as described in a 'Theory of Himalayan Environmental Degradation' (Ives and Messerly 1989).

The trade-off between fodder extraction and fodder resource availability from forests is critical for conservation in Himalayas where livestock is an important source of livelihood for rural communities. Himalayan mid-elevation landscapes function as complex agro-ecosystems where management and conservation of natural resources need to strike a balance fodder requirements and utilization practices of diverse users while meeting biodiversity conservation and sustainability criteria (Maren and Vetaas 2007). This balance may be obtained by implementing effective policies for forest conservation and satisfying needs of fuelwood and fodder of communities (Pandey 2011a, 2011b, 2011c).

This paper reports an empirial analysis of fodder resource availability and use by forest dependent communities in the rural mountainous region of Uttrakhand in India The basic assumption is that farming households have an understanding of the fodder requirements and are able to predict forest growth. This study investigates the availability of forest fodder resource stocks across forest density classes. The relationship between fodder consumption and household characteristics is examined with a view to identify policies for preventing further degradation of hill forests and improving the productivity of livestock. In particular, the paper analyses the tradeoffs between the fodder biomass available in forests versus the extraction, and the need for a customised management perspective for sustaining and conserving the forests.

The Study Area

The study focuses on all the region of Uttarakhand State except upper snow-covered areas in the Indian Himalayan region. The study area has a temperate climate in the higher hills and is sub-tropical in lower hills and plain region, with tremendous diversity of altitude, climate, landform, resource availability, biodiversity, ethnicity, culture and farming system. The region is sparsely populated in small settlements with high dependence on rainfed agriculture and adjoining forests. Little or no cropping is practiced at high elevation due to steepness of land, prolonged and severe cold winters, shallow soils and lack of irrigation (Inder Dev 2001). Therefore, livestock rearing forms an important occupation in the mountainous areas (Singh 1995), and provides manure for crop cultivation and milk products for household consumption, contributing about 20 % of household cash income (Tulachan and Neupane 1999).

The study region (Uttarakhand State) lies from 28′43″N to 31′28″N latitude and 77′34″E–81′03″E longitude with a land area of 53,485 km^2. The recorded forest area (demarcated land under forests) is 34,651 km^2 with forest cover of 24,496 km^2. The major tree species found in the State are *Shorea robusta* (sal), *Acacia catechu* (khair), *Bombax ceiba* (semal), *Cassia fistula* (kanju), *Dalbergia sissoo* (shisham), *Adina cordifolia* (haldu), *Pinus roxburghii* (chir pine), *Cedrus deodara* (deodar), *Abies pindrow* (fir), *Picea smithiana* (spruce), *Betula utilis* (birch).

The population of Uttarakhand is about 10 M (0.84 % of the national population) of which the rural population accounts for 69.45 % (Census of India 2011: Provisional Data). Human inhabitants live mostly below an altitude of 3,500 masl, the zone between 1,200 and 2,000 m being densely populated. Mixed-cropping farming is prevalent in the region. Rain-fed rice, wheat and various millets are the main food crops. The State has 1.18 % of cattle, 1.25 % of buffaloes, 0.48 % of sheep, 0.93 % of goats and 0.24 % of pigs, of their respective populations nationally, with a total of 4.3 M adult cattle units (ACU)[1] (Ministry of Agriculture 2005). The livestock fodder in the region is derived from a variety of sources including forests, non-forest areas and local markets. The major fodder trees and shrubs species of the region are *Quercus incana* (banj oak), *Grewia oppositifolia* (bhimal), *Ficus palmata* (beru), *F. glomerata* (gular), *Bauhinia variegata* (kuiral) and *Melia azedarach* (bakain). The major share of leaf fodder comes from banj oak and bhimal.

In the region, stall-feeding is frequent for buffaloes but cows and oxen are generally grazed outdoors. Grazing takes place in the forests from morning to evening throughout the year generally under the supervision of male adults and children. Fodder is collected by cutting small branches of leafy trees by traditional knives or choppers, either by climbing the trees or from the ground. Grasses and shrubs are also cut and carted for stall-feeding. The collection generally takes place during morning throughout the year and is practiced by women and children. In some areas, dried grass is fed to livestock during summer due to shortage of fodder and grazing resources.

Research Method

A household survey was conducted to investigate forest resource availability in Uttarakhand State. Four strata of households were defined, based on the forest density classes as defined by the Ministry of Environment and Forests (MoEF 2009) as an indicator of resource availability. The density classes are *very dense* forest (with more than 70 % canopy cover), *moderately dense* forest (40–70 % canopy cover), *open* forest (with 10–40 % canopy cover) and *scrub* (with less than 10 % canopy cover) (Fig. 1). The area under forest canopy spread in the respective classes is 4,762, 14,167, 5,567 and 271 km^2 respectively.[2]

The sample comprised 316 randomly selected livestock rearing households in 66 randomly selected villages of the State. These villages were selected roughly on proportional basis to country's forest cover distribution among forest density classes defined by MoEF. Twenty two sample households (7 %) were in the high-density forest class, 112 (35 %) in the moderate-density class, 66 in open forests (21 %) and 116 (37 %) in scrub and grassland. A questionnaire was developed to obtain information about households and livestock, and sources and consumption level of livestock feed and

[1] Livestock numbers are aggregated in terms of an Adult Cattle Unit (ACU); 1 goat = 0.15 ACU, 1 pony = 1 ACU, 1 ox = 1.15 ACU (Yang 1971), and 1 buffalo = 1.5 ACU (G.B. Pant University 1980).

[2] The MoEF mapped the land according to forest density class by selecting patches that fitted into the four forest classes. Farming households near these patches were grouped within the forest density class as sampling strata, even though they sometimes operated with mixture of forest land types.

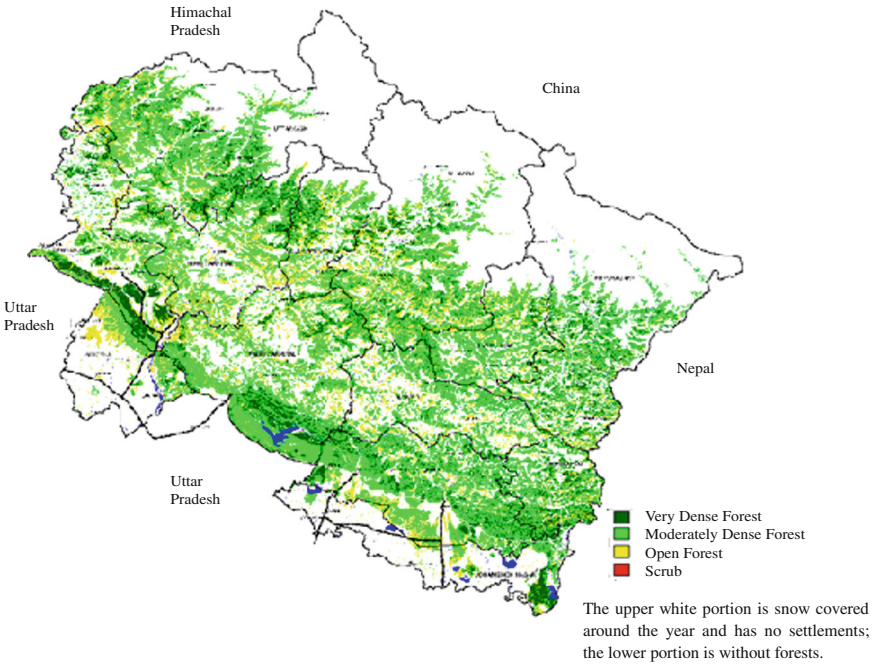

Fig. 1 Forest canopy density class map of Uttarakhand. *Source* Ministry of Environment and Forests (2009)

fodder. The feed sources for all households were categorized into forest areas and non-forests areas and markets. The questionnaire was tested with 20 households and changes were made to the classification of sources of livestock fodder by dividing these into three categories, namely forest, open land and market (purchased fodder).

Information was collected through personal interviews with household heads. Personal observations were made and discussions held with villagers to substantiate the information. The fodder consumption shares from the three sources were estimated and compared across forest density classes through the non-parametric Kruskal–Wallis H (KWH) test. The KWH test was used because the mean fodder quantity by forest density class could be assumed to follow a normal distribution with heterogeneous spread. The KWH test examines the differences in the mean of more than two samples based on ranks. Data were coded and analyzed by using SPSS 7.5 (SPSS Inc 1997).

Results and Discussion

Socioeconomic Conditions and Fodder Contributions From Forests

The average household size in various density classes varied from 5.36 persons in the open land class to 6.34 persons in the moderate forest density class (Table 1). The majority of people more than 60 years of age were found to be uneducated,

whereas almost all children were attending school. While the literacy rate was high among young people, 65 % were unemployed due to lack of employment opportunities in the rural area. The average cultivated area per household across all four sample strata was less than 0.5 ha (Table 1) due to hilly terrain and lack of irrigation facilities. Scarcity of agricultural land is leading to supplementing agricultural income by livestock with increasing demand for fodder resources from forest and non-forest areas. More than 90 % of the agricultural land is rainfed in all the locations across all forest density classes.

The mean annual cash income per household ranged from Rs 4,272 (US$ 95) to Rs 5,178 (US$ 115) in the four sample strata (Table 1). This income range is well below the Poverty Line based on cash income prescribed by the Government of India for rural households of Rs 12,000 or US$ 266 (as reported by (Sharma et al. (2009). The lower average income for households in the very dense forest class area is probably due to high-elevation and remote location (Table 1), with limited infrastructure and accessibility, both in terms of off-farm work and markets, and therefore low opportunity for income generation.

Most of the population practice more than one profession for their survival, with agriculture as the main occupation, practiced by 60 % households across the State. More than 40 % of households earned some income from working as labourers, as a secondary occupation. A small number operated off-farm businesses or had salaried employment. Poor people worked in MNREGA (an employment guarantee scheme) of the Government of India, the forest department and welfare schemes run by the government, but seldom worked in other developmental activities such as construction of roads or hydroelectric projects.

Correlation analysis reveals a positive significant relationship ($r = 0.29$) between income and total area of landholding, which confirms the critical contribution of agricultural land in the household economy of the sampled rural people. Household income is positively related to family size, i.e. families with more members have greater incomes than smaller families. A greater labour supply increases the opportunity to derive income from primary and secondary occupations, as well as manage a greater crop area. No significant relationship was found between number of livestock and total landholding area or household income, i.e. irrespective of household economic status people of the region rear livestock. Livestock provide milk products and draught power rather than earning of cash income. Household income was not related to quantity of fodder consumed, because livestock feed is mainly collected from the adjoining forests and farm land.

Livestock Profile and Fodder Requirement

The average numbers per household of cows, buffalos and goats were 1.58, 0.97 and 1.36, respectively. No cows were reared by 24.4 % of households. Most of the livestock were indigenous (native), with low milk production. Local species are being reared probably due to their better adaptability and resistance to diseases in these hostile conditions as well as low cost of maintenance for fodder. Low fodder availability, malnutrition and poor genetics are prominent causes of low productivity, as reported by sampled villagers. Nevertheless livestock are considered to be

Table 1 Descriptive characteristics of livestock rearing households in Uttarakhand State (mean ± SE)

Parameter	Household location strata (MoEF classification)			
	Very dense	Moderately dense	Open forest	Scrub and other land
Sampled household (316)	22 (7)	112 (22)	66 (13)	116 (24)
Family size	5.55 ± 0.51	6.34 ± 0.24	5.36 ± 0.18	5.73 ± 0.11
Income (Rs)	4,272.7 ± 302.8	5,178.6 ± 149.1	4,969.7 ± 174.1	4,758.6 ± 126.4
Irrigated area (ha)	0.30 ± 0.16	0.39 ± 0.09	0.24 ± 0.11	0.13 ± 0.04
Non-irrigated area (ha)	4.92 ± 0.70	3.89 ± 0.25	4.27 ± 0.28	4.63 ± 0.27
Number of adult cattle unit (ACU)	3.91 ± 0.37	4.72 ± 0.19	4.86 ± 0.24	4.89 ± 0.20
Quantity of dry fodder from other than forest (kg/day)	7.61 ± 0.71	7.76 ± 0.37	11.03 ± 1.36	10.53 ± 1.06
Quantity of green fodder from forests (kg/day)	14.92 ± 1.51	14.67 ± 0.72	9.83 ± 0.80	11.05 ± 0.74
Quantity of mineral mixture purchased from market (kg/day)	0.31 ± 0.05	0.37 ± 0.04	0.35 ± 0.03	0.32 ± 0.03
Time spent on fodder collection from forest (person hrs/day)	2.46 ± 0.17	2.69 ± 0.08	2.62 ± 0.12	2.61 ± 0.06

important assets and a symbol of social status in the community. Goats and hens were used as meat, and often sold for income.

Fodder collection from forests and non-forest areas is routine work, and practiced mostly by females. During the rainy season, fodder is collected twice daily, but collection during winter is less frequent, sometimes only on alternate days in higher zones. The per day average time spent was found to be more than 2 hours, ranging from one to more than 5 hours (or 1–5 km in distance) depending on the distance of households from fodder source areas. The fodder was collected in small bundles, called *phula* and brought to households by headload or backload. The grasses were in some cases and some locations dried for storage in the households for lean periods (summer).

The sources of fodder also changed between seasons depending on availability and accessibility. Fodder was collected from private land by 67 % of households, from grassland (common) by 62.7 %, and from forests by 83.4 %. About 15 % of households purchased fodder, particularly grasses and straw, from other households during severe scarcity. Grazing was also a major activity for livestock, with more than 60 % of households reporting they visited forests and grasslands during the survey year to supervising their grazing animals. Animals were also grazed on farmland and other non-forest land. Table 2 summarizes the relative importance of each fodder source to farms in each of the four sample strata. Grazing was observed to be harmful to the ground flora and inhibited regeneration of dominant tree species in the area.

Table 3 reports quantities of livestock feed obtained from each of the three fodder sources (forest, non-forest areas and local markets), for the four sample strata. These feed and fodder are mineral mixture, oilseeds and cake, bran and salt from markets; dry fodder (includes all fodder) from the outside forest area, and fodder sourced from forests. The dry fodder from non forest area was straw and dry grasses received from agriculture farms with low proportion of green tree foliage. The green fodders from forest include tree foliage, shrubs and fresh dried grasses.

The average quantity consumed per day by one ACU ranged from 9.85 to 14.70 kg for forest area, 7.40–11.14 kg for non-forest area, and less than 1 kg from market. Forests contribute more than 50 % in all sample strata (MoEF forest density classes) with the greatest contributions in dense and moderately dense forest classes. The contribution from non-forest areas was comparatively higher for low-density forests. The ratio ranges between 33 % and 46 % for non-forest area, 49–63 % for forests and 2–3 % from markets (Table 3). These ranges of estimates are in agreement to the Tulachan et al. (2002). However, they differ from the estimates of Tripathi (1999), perhaps due to the general degradation of forests in the high anthropogenic pressure mid-hills areas, which has reduced the fodder availability to livestock, as also observed by Tiwari (1997). The low contribution of forests in open forest strata was probably due to the lower availability of forest fodder biomass and green flushes (i.e. foliage) as well as easy availability of agricultural residue from non-forest land.

The analysis clearly indicates that fodder extraction is greater from forests with high tree cover, where fodder is readily available and without monetary costs. However, the fodder contribution from non-forest areas to livestock is not

Table 2 Proportion of households in each sample stratum grazing livestock on each land type (%)

Land type where grazing took place	Household location strata (MoEF classification)			
	Very dense	Moderately dense	Open forest	Scrub and other land
Forests	64	78	73	67
Grassland	68	78	74	77
Village land	27	13	12	19
Other commons	9	6	6	7
Farm land	50	38	44	50

significantly different across the four land classes. The results of KWH tests for feed from forest areas and non-forest areas are reported in Table 4.

Conclusion

An estimated of aggregate forest fodder for livestock of 0.012, 0.036, 0.009 and 0.005 MT was being extracted annually under very dense, moderately dense, open and scrub areas of the forests respectively. The high extraction rate of fodder from relatively high-density forests is probably due to free availability of forest resources and unavailability from other sources for livestock feed. The unavailability of fodder from other sources may be attributed to either lack of common village land or low productivity of common land as well as marginal and small landholding size limiting fodder cultivation. This exacerbates fodder extraction from forests and consequent land degradation. A similar observation was made by Whyte (1968), who noted that this situation has persisted for decades in the region. The unavailability of fodder from other sources contributes to degradation of forest areas, because these are more frequently used and are vital for existing farming systems. This trend of fodder extraction is more pronounced for the forests with high canopy cover. Thus, it may be argued that high extraction from high density forests is due to high resource availability, and may be a potential reason for forest degradation in the Uttarakhand Himalayas. This finding is also supported by the forest inventory data, in terms of the cross-sectional and temporal data of forest cover collected by the Forest Survey of India (Ministry of Environment and Forests 2009) and reinforced by respondents during the survey. Therefore, the strategy for reducing forest degradation must revolve around providing alternatives fodder sources to the community for livestock rearing while encouraging protection of the forest cover, as also advocated by Sills et al. (2003).

The high fodder extraction rate from dense forests may further lead to conversion to lower density classes and ultimately to deforestation. The shifting of high density forests to lower density classes is corroborated in the reports of MoEF (2003, 2009). During the survey, respondents also expressed the opinion that adjoining forest biomass stocks have been decreasing. Under such a scenario, it may be argued that

Table 3 Quantity of livestock feed derived from various sources (kg/ACU/day)

Source of livestock feed item	Household location strata			
	Very dense	Moderately dense	Open forest	Scrub and grassland
Forest fodder	14.52	14.70	9.85	11.05
Fodder from non-forest areas	7.40	7.78	11.14	10.53
Purchased fodder—minerals, bran, cake and other supplements	0.56	0.70	0.63	0.67
Total	22.47	23.18	21.62	22.25

the absence of focussed programs providing alternate livestock feed options hamper the impact of other programs of forest conservation. Encouraging the practices of agroforestry on farmland and growing farm fodder crops may be possible alternatives in the region. This view has also been expressed by Ives and Messerly (1989) when analysing linkages between conservation and forest extraction.

Reduced emissions from deforestation and forest degradation (REDD) activities may further help to address the degradation of the forests by an effective community protection mechanism with a focus on forest sustainability. The additional income generated due to marketing of carbon sequestration credits may further strengthen the household economy and thereby help to reduce forest dependency.

Policy Implications

The high rate of forest fodder extraction is not sustainable. The trade-off between meeting the livestock feed deficit and protecting forests clearly requires careful attention and adapting current policies.

The livestock feed scarcity together with the need for protection of forests requires attention by the by the government, because there is a lack of direct involvement of the community in forest management. The community at the expense of their own labour extract the forest fodder. Therefore, either their labour may be potentially remunerated (either through payment for forest-protection and conservation activities) or they may be allowed to extract forest resources on a limited basis in lieu of their services in forestry-related activities, or a suitable combination of both options may be adopted. The suggested system may not disturb the critical balance of availability of resources in forests. This arrangement will ultimately fulfil household needs either through earning or saving of resources keeping in view the low socioeconomic status of the people of the region and poor infrastructure, especially in areas with forests of high and moderate density.

The community may be involved in forest protection or planting with permission from government for extraction of limited resources depending on the density of forests, so that forest condition can be maintained in the future. Collection of forest resources may be allowed either through sustainable lopping of trees (mainly in dense and moderately dense forests areas) or sustainably cutting of ground flora

Table 4 Result of Kruskal–Wallis H-test for feed under various forest density classes

Feed item	Mean ± SD (kg)	Household location strata				KWH-test statistics (p value)
		Very dense	Moderately dense	Open	Scrub and other land	
Fodder from non-forest areas	9.45 ± 9.01	152.75	152.92	167.38	159.93	1.16 (0.76)
Forest fodder	12.35 ± 7.71	193.02	186.30	138.96	136.22	23.45 (0.00)

(mainly in open and scrub areas). The balance of fodder needs may be obtained from other sources from either farms or from village land, or may be purchased from markets. This will assist in maintaining the health of forests. Another policy measure may be to assign small patches of forest land to groups of households in near villages, who will be allowed to extract sustainable quantities of fodder, based on their traditional knowledge and experiences about forest growth and development. The group of households should be encouraged to grow fodder on their farms to meet the remaining requirements. These groups should promote management of forest resources in the light of the government rules and regulations, without disturbing the composition and structure of the forests. The recent *Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of* Forest Rights*)* Act, 2006 enacted by Government of India also confers on forest communities and traditional dwellers the right to manage their forests, taking into account the availability, use and future demand of forest resources.

The policy options should also address the role of community in forest management through intensification of forest tree farming on the farmland. The growing of high yielding fodder such as *Q incana*, *G. oppositifolia*, *F. palmata*, *F. glomerata*, *B. variegata* on farms with fodder trees on farm boundaries may also be a sustainable options. The improvement in existing unproductive land by growing fodder and fuelwood tree plantations would further help to meet the demand of fodder. In brief, policy options should be three-pronged, i.e. involvement of community in forests management (especially for the areas under dense forest), intensification of farm fodder production and better use of village land.

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